



The Region

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Time to Remodel? [\[In Brief\]](#)

Fed researchers suggest that two core models used by economists are seriously flawed

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Models are the test jets of modern economics. As mathematical representations of economic theory, they allow economists to see if their ideas can take flight in the face of reality. Like the Wright brothers, whose models contended with gravity, wind and a host of other real-world variables, economists test their theoretical models against the concrete realities of taxes, interest rates, hours worked and so on. When models fail to match data, the theories behind them may crash and burn. With luck, the model will just need a bit of tinkering—a thicker wing, an altered parameter.

In two recent Research department staff reports, Minneapolis Fed economists, working with scholars from other institutions, suggest that commonly used economic models fail to fly. (As it happens, two of these economists also are brothers.) The papers tackle quite different topics. The methods vary. But they both reach a remarkably similar conclusion, and that conclusion is quite disturbing.

One paper ([SR 391](#)), by Fed consultant Tim Kehoe, a University of Minnesota economist, and Kim Ruhl of the University of Texas, Austin, examines the relationship between terms of trade and productivity—a link strongly supported by data and often pointed to by economists as a robust explanation of why some nations prosper and others don't. Kehoe and Ruhl show that standard economic models don't support this intuitive notion.

The other paper ([SR 388](#)), by Fernando Alvarez of the University of Chicago, Minneapolis Fed consultant Andrew Atkeson of the University of California, Los Angeles, and Fed monetary adviser Patrick Kehoe, looks into the standard models used to analyze monetary policy and determines that they "capture essentially none" of what goes on with interest rate adjustments. "We thus argue that almost everything we say about monetary policy using these models is wrong," they write.

In essence, then, both staff reports find a major disconnect between models and data—theory and reality—that could have major import for policymaking. Are central banks using faulty models in their deliberations over interest rates? Are international economists reaching flawed conclusions about the sources of long-run growth and volatility? If these papers are correct, the answer to both questions is a disconcerting "Yes."

The terms of trade

Economists have long suspected that a nation's productivity and output are strongly affected by its terms of trade—that is, by the relative prices of its imports and exports. If one views foreign trade as a type of production technology (exports are fed into the production process and transformed into imports—think of the United States exporting crops to Japan and using the proceeds to import autos), then the relative prices of exports (wheat) and imports (Hondas) determine the rate at which exports are transformed into imports. "Viewed in this way," write Kehoe and Ruhl, "an increase in the terms of trade acts much like a technology shock: the same amount of exports now produces a smaller amount of imports."

The economists provide a couple of well-known examples. The 1973 OPEC oil embargo and the 1979 revolution in Iran both caused sharp spikes in the price of imported oil, and both price shocks led to immediate drops in U.S. gross domestic product growth. Similarly, debt crises in Mexico in 1983 and 1995 caused import prices to surge and GDP to contract. In both countries, productivity—units of output produced per unit of input—also dropped when the terms of trade rose.

These are not isolated cases. A 1993 study of 115 countries by Richard Easterly and colleagues found that "shocks, especially terms-of-trade shocks, statistically explain as much of the variance in growth rates over 10-year periods as do country policies."

A 2005 International Monetary Fund analysis used data for 1900-2001 from a large panel of countries to compute the costs of various shocks such as currency crises, wars and natural disasters. The researchers found that "the largest costs are associated ... with real external shocks (in particular, terms-of-trade shocks) for developing countries." Such shocks incur a cost of about 2 percent of GDP annually in developing nations, they estimated.

"The empirical literature on growth," conclude Kehoe and Ruhl, "is replete with examples of the association of the terms of trade and output growth."

Misbehaving models

It follows, then, that economic models hoping to resemble real-world economies should be able to mimic this empirical association. So Kehoe and Ruhl look at a variety of standard models, starting with the most basic: a single unvarying factor of production (labor) and no distortions.

Unfortunately, the model's math shows that a deterioration in the terms of trade generates no change in measured real GDP or productivity. The relationship so evident in the data can't be reproduced by the model. Indeed, "real GDP may even increase in response to a negative terms of trade shock."

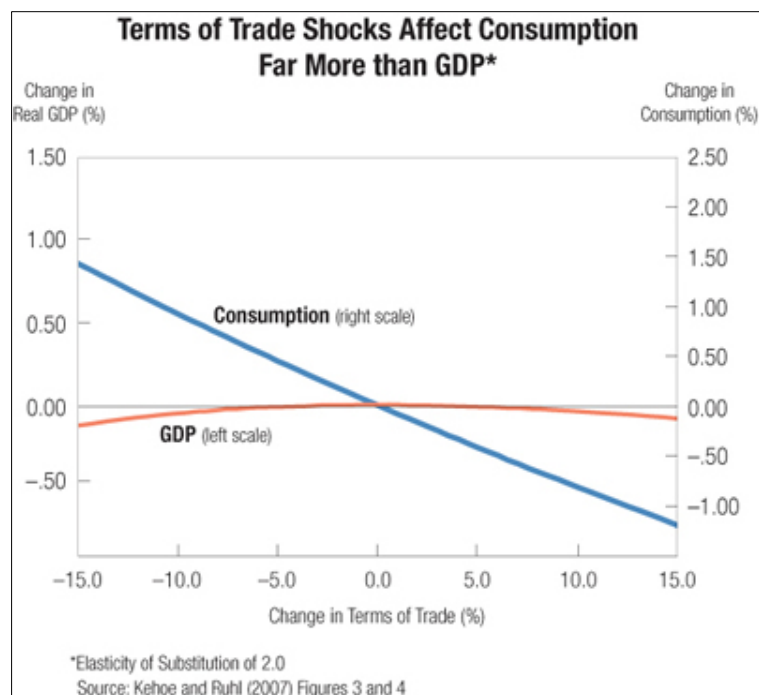
Extending the model—making labor supply responsive to wages and introducing distortions like trade tariffs—doesn't help much. In a model where labor is sensitive to wages, real GDP can either rise or fall with an increase in the terms of trade, but productivity does not change. A model with tariffs is more complicated, but again, there are "no first-order effects on GDP."

Income and consumption

The result is baffling. How could such a major change—prices of imports rising or falling relative to exports—not affect output or productivity? And if not output and productivity, what *is* affected when terms of trade shift? As it turns out, standard models do produce expected results in regard to *consumption*, the real determinant of welfare. And in this lies at least part of the answer to the mystery of unaffected GDP.

When imports become more expensive for a nation relative to its exports (that is, the terms of trade deteriorate), the purchasing power of that nation declines. Consumption therefore declines, as does welfare. And it comes as something of a relief to find that the standard economic models analyzed by Kehoe and Ruhl validate this intuition.

Using a standard model, they show that while real GDP is barely affected by a terms of trade shift from -15 percent to +15 percent, consumption drops from a 1.5 percent rise (relative to constant terms of trade) to a 1 percent decrease (see chart). "Although an increase in the terms of trade has little effect on real GDP," conclude the economists, "its effect on consumption can be significant."



Therein lies the irony. GDP is usually held forth as a measure of national well-being. Countries are ranked according to their per capita GDP. Economic progress is judged by comparing GDP, adjusted for inflation, from one year to the next. But Kehoe and Ruhl are pointing out that standard economic models are unable to duplicate the relationship between terms of trade and GDP seen in the data, even though these models do generate the underlying relationship between terms of trade and economic welfare.

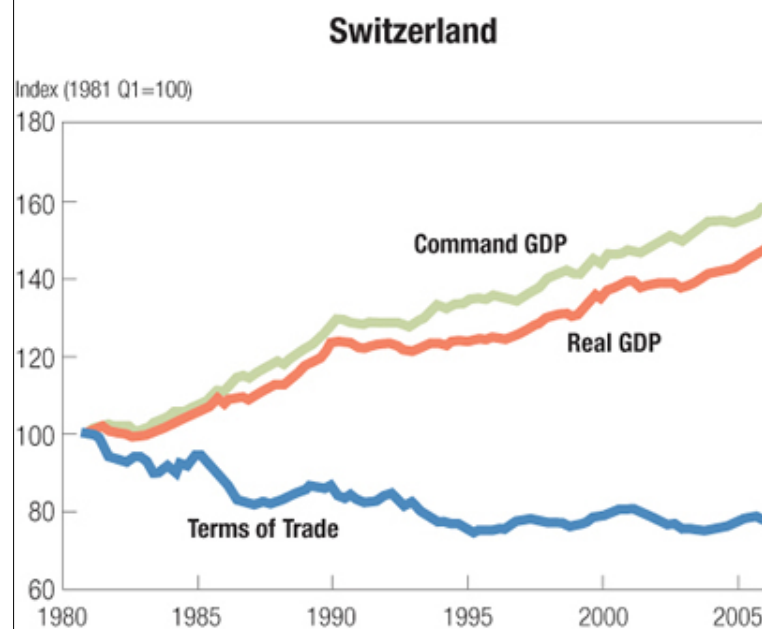
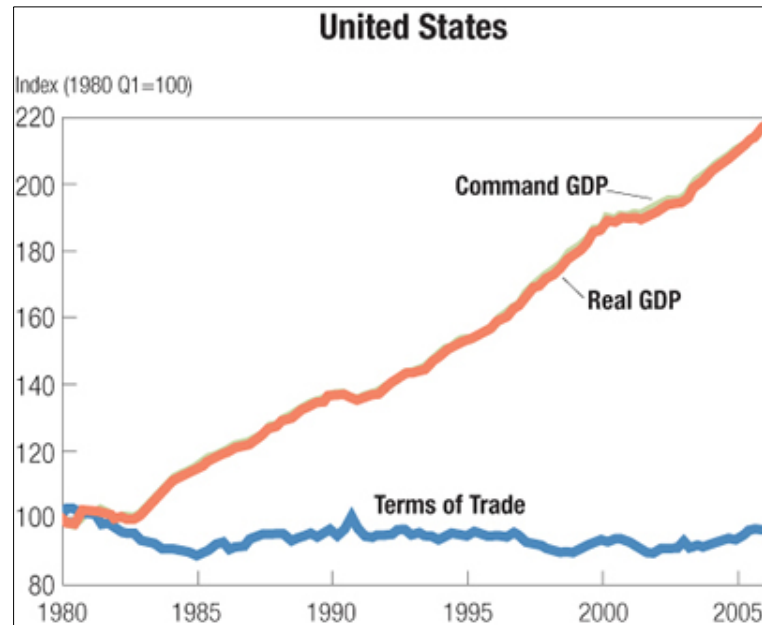
It would seem, then, that a better measure is called for, a statistic that allows economists to more accurately model what's seen in the data and to better reflect the underlying structural relationship of the economy. "If real GDP does not accurately reflect the real purchasing power of an open economy," ask Kehoe and Ruhl, "are there measures that do?"

They focus on one: a statistic that goes by a rather ominous name, "command-basis GDP." Essentially, command-basis GDP is the same as real gross domestic income, or real GDI, which differs from real GDP in one crucial way. "The difference ... arises from the deflation of the trade balance," observe the economists. Whereas real GDP, a measure of production, values

exports as an output and imports as an input, “real GDI values the nominal trade balance in terms of the amount of imports that can be purchased.” In other words, command-basis GDP, or real GDI, reflects a nation’s true purchasing power because it adjusts for the relative prices of imports and exports.

(A note on terminology: “Command-basis GDP” and “real GDI” refer to the same thing, but the terms come from different accounting systems. The first is part of the U.S. Bureau of Economic Analysis’ National Income and Product Accounts (NIPA); the second is part of the United Nations’ System of National Accounts (SNA), a system used by virtually every other nation in the world. NIPA also uses the term “GDI,” but it refers to something quite different from SNA’s GDI. In this article and in Kehoe and Ruhl’s, “GDI” is used in the SNA sense of the term, identical to NIPA’s “command-basis GDP.”)

For some nations, there is little difference. Where the terms of trade are fairly stable—the United States, for example—real GDP and command-basis GDP are similar. Charting their course over the past 25 years, the economists find the two “almost indistinguishable” in the United States. In contrast, Switzerland, which has enjoyed a steady improvement in terms of trade since 1981, has seen its command-basis GDP grow “significantly faster” than real GDP; over the past 25 years, in fact, Switzerland’s command-basis GDP has grown 18 percent more than its real GDP (see charts).



Source: Kehoe and Ruhl (2007) Figures 5 and 6

Underlying structure

While choosing the right measure for a nation's purchasing power helps economic models link terms of trade shocks and output shocks, it does little to illuminate the economic mechanism that connects the two—in reality and in corrected economic models. That is, how is it that a change in the relative prices of imports and exports affects productivity and output?

"Factor movements are one potential explanation," suggest Easterly et al., in their 1993 study. Labor and capital might flow to the sector benefiting from a terms of trade shock, or capital might flow in from abroad to the export sector. Similarly, Kehoe and Ruhl argue that changes in relative prices could lead to reallocations across goods and sectors. In the case of deteriorating terms of trade, resources might shift to activities like job retraining that have no immediate output result, or capital could go idle. "[B]oth contribut[e] to lower output and measured TFP (total factor productivity)."

"Progress is being made in modeling the frictions that may help account for the relationship between the terms of trade, real GDP and productivity," Kehoe and Ruhl observe. "But the exact specification and the quantitative importance of these frictions remains a question for future research."

Monetary Models

For as long as economists have walked the earth, they've debated whether interest rate changes affect only prices or also the "real" economy. If the Fed adjusts its target for the short-term interest rate, goes the debate, will that affect just the rate of inflation, or will it alter the pace of economic growth?

To analyze this question, economists have developed sophisticated mathematical models in which nominal interest rate changes are "decomposed" into their impact on three elements: (1) average expected growth in the marginal utility of consumption—the "real effect," (2) average expected inflation—the "nominal effect" and (3) a term representing the statistical variances of consumption and inflation. (Variance is dispersion around the statistical mean, or average—more on this below.)

Economists have generally assumed that this third term is a constant, and so any change in nominal interest rates must influence either the first or second term (or both, perhaps). "The debate in monetary policy analysis is over how changes in the nominal interest rate are divided into these two types of effects," observe Fernando Alvarez, Andrew Atkeson and Patrick Kehoe, in Minneapolis Fed [Staff Report 388](#).

One camp vigorously argues that monetary policy is "neutral": Prices adjust quickly to interest rate changes so people perceive no change in relative values of goods and services; thus monetary policy affects only expected inflation. But the other school of thought contends that wages and prices adjust slowly, and such "frictions" mean that interest rate changes have real as well as nominal effects.

A serious problem

The debate has been the source of much discord between those considered neoclassical economists and those who call themselves Keynesians. But the dispute, suggest Alvarez, Atkeson and Kehoe, is largely misdirected—focused on the wrong part of the equation.

"It assumes," write the three economists, "that changes in interest rates affect only the conditional *means* of endogenous variables, not conditional *variances*." In other words, the spotlight has been on the first two terms of the equation—mean (or average) growth in utility of consumption and mean inflation—and has taken for granted that the third term—the variances—is constant.

"This, as we shall see, is a serious problem," they write. "The problem is that the data contradict that assumption."

To prove their point, Alvarez, Atkeson and Kehoe build a model of an economy that includes two countries with independent currencies and monetary policies. In the model, interest rate differentials between the countries equal the sum of two elements: expected changes in the exchange rate and a term involving variances.

But trend data on exchange rates between major currencies, the economists observe, "are well-approximated by random walks"—meaning that they exhibit no systematic, predictable path. The expected change in the exchange rate, therefore, is "approximately a constant."

Since the first term of their model economy is a constant, any change in the interest rate differential between two countries must affect the second term: variances.

"Why should this discrepancy trouble users of standard monetary models?" ask Alvarez, Atkeson and Kehoe. "Because it reveals that their standard debates about how to divvy up the effects of interest rate changes into real and nominal effects are debates about terms that are essentially constant. The standard monetary models, that is, have nothing to say about the terms that are actually affected by interest rate changes, the conditional variances."

Deviation, not norm

"Conditional variances." Not an everyday phrase, but actually quite a familiar concept. "Variance" is a measure of dispersion in a group, an indication of how broadly the values of a variable are spread around the average. A group of three dozen

people, say, with an average (or “mean”) age of 17 years would have a low variance if they were high school students—since the age variation would be small—but a much higher variance if the group were a family reunion, with babies and grandparents in the mix. If we’re talking about economic variables over time, like gas price or stock index trends, a more intuitive interpretation of variance might be “volatility” or “market turbulence.”

When “conditional” is added to “variance,” it simply means that the dispersion or volatility depends on the occurrence of some other event. So it’s the variance *if* such-and-such happens.

It all boils down to a statistical measure of *risk*—an indication of instability rather than central tendency, deviation rather than norm. The concept still might seem abstract, but when it comes to economic variables such as asset values, risk has very real meaning.

“Risk is about the payoffs and *when* something will pay off vis-à-vis when you want it,” observes Kehoe in an interview. He uses stocks and bonds as an example. “People hold both stocks and bonds even though stocks have a much higher mean, or average, return,” he says. “That’s because stocks have a lot more volatility than bonds—so a higher mean but also a higher variance.”

People gauge risk intuitively (and not always accurately) by balancing higher average payoffs against higher variation in payoffs, knowing that variability could have an adverse impact when the cash is needed. “If you hold just stocks and you’re trying to finance a college education, you may go to sell the stocks and find they’ve lost 50 percent of their value,” says Kehoe. “And that’s all about risk.”

Changing risk premia

Investors demand a “risk premium” to compensate them for taking on higher variance, and Alvarez, Atkeson and Kehoe argue that “changes in conditional variances ... can be interpreted as critical economic variables: changes in risk premia.” Because their model demonstrates that interest rate changes lead to conditional variance changes, it follows that “changes in monetary policy affect the economy primarily by changing risk.”

In other words, the primary impact of interest rate changes by the Fed and other central banks is not on average inflation rates or consumption growth—the traditional focus of economic debate—but on systemic risk in the economy at large.

“What we’re suggesting,” says Kehoe, “is that when we think about Fed policy, we really should be thinking about the Fed changing the risk in financial markets.” Usually when economists discuss monetary policy, they debate average trends in inflation and real economic activity, so “the only fight is, is it real or is it nominal?” he continues. “We’re saying, ‘No, it’s neither of those. It’s risk. Risk went up or risk went down.’ But instead of looking at changing risk, most economists are instead decomposing something that’s essentially constant.”

While it’s possible that the apparent association between interest rates and conditional variance changes is due to a third factor—that is, perhaps something else changes financial risk, and central banks simply react to that change—the economists say the evidence suggests otherwise. “A brief review of recent U.S. and U.K. monetary policy,” they write, “suggests that at least lately the causality has been from changes in interest rates to changes in risk premia.”

Future work

In their staff report, the economists draw on exchange rate data to make their point, but by no means is the phenomenon limited to exchange rates. They focus on them simply because they provide a clear, mathematically simple example of risk—specifically, the risk that the value of one currency will change relative to another.

A forthcoming paper will extend the idea to other arenas. “Exchange rates are just one simple way to see this point,” says Kehoe, “but we’re doing the same analysis with other markets. You just need two classes of risk: short-term bonds versus long-term bonds, for instance, or risky stocks versus less-risky stocks.”

Indeed, the current staff report is just part of a broader research agenda in which the three economists are developing economic models that clarify the relationship between policy changes by central banks and variations in systemwide economic risk. In Minneapolis Fed [Staff Report 371](#) issued in March 2006, for example, the economists developed a model based on the idea that asset markets are segmented in the sense that people choose whether or not to participate in them, and “monetary policy affects risk by endogenously changing the degree of market segmentation.” Future work will expand on this research.

In the meantime, the economists have cast serious doubt on the explanatory power of current monetary models. “Determining how changes in an asset price, the short-term interest rate, affects the economy is clearly at the heart of monetary policy analysis,” they observe in [SR 388](#). But since their analysis shows that standard models can’t explain these effects, they are left with the very stark conclusion: “If these data are accurate, then almost everything we say about monetary policy is wrong.”

The bottom line

Two studies, one conclusion: When compared to the data, standard models don’t cut it. Ordinary macroeconomic models can’t convincingly connect terms of trade shocks to changes in economic output and productivity, and conventional monetary models can’t really explain the effects of interest rate changes. These failings are so glaring, they seem to undermine much of macroeconomics. Are the findings really so dire?

Obviously not. The authors of both papers take pains to describe promising paths for future research. Kehoe and Ruhl describe better statistical measures and suggest directions for modeling frictions that could explain why shocks in terms of trade lead to shocks in output and productivity. Alvarez, Atkeson and Kehoe have already developed a model in which monetary policy affects the economy by changing risk, though they call their effort "only a first, simple step."

So to a large extent, these papers serve as a warning to fellow researchers. Indeed, they both end with remarkably similar notes that credible data seriously undermine existing economic models. Much work remains to be done, they caution, and relying on old models entails serious flight risk.

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